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MADRAS: PRINTED BY THE SUPERINTENDENT, GOVERNMENT PRESS

CONNEMARA ... 1955 ... MADRAS

Electricity Under the Plan

V. P. APPADURAI, B.A., M.I.E. (Ind.),
Chief Engineer for Electricity.

(This article is reproduced from the Madras Information Annual Number, January 1955.)

THIS ARTICLE is intended to give an idea of the progress, since April 1951, the commencement of the Five-Year Plan, in the field of Electricity. Development in the Madras State.

The capital invested and in operation increased from Rs. 18·44 crores to Rs. 29·09 crores, i.e., by 58 per cent while the annual gross revenue increased from Rs. 337 lakhs to Rs. 481 lakhs, i.e., by 43 per cent. Outlay on construction of new projects touched record figures each year during this period, and outlay on construction works yet to come into operation is Rs. 8·19 crores.

The installed generating capacity increased by nearly 60 per cent, from 156,000 KW. to 247,300 KW. The principal additions to power generating capacity comprise :—

	KW.
1. A new power, station under the Moyar Hydro-electric Scheme ..	36,000
2. Additions to existing power stations, viz.—	
(a) Papanasam II Stage (hydro)	7,000
(b) Madurai Thermal Station (thermal) ..	10,000
(c) Madras Thermal Station (thermal I stage)	15,000
(d) Pykara III Stage Extension (hydro).	27,200
Total ..	95,200

The Plan target in generation for the first three years has been achieved and in fact the full Five-Year Plan target itself will be realized by the end of 1954 when the II Stage of the Madras Thermal Station is expected to be commissioned, bringing an additional 15,000 KW. generating plant capacity.

Power demand met and energy generated in 1950–51, the year preceding the Plan, and in 1953–54 are as below :—

	1950–51.	1953–54.
Aggregate power demand in KW	130,850	169,000 (Sep. 1954).
Total number of units generated in Government Power Stations in millions ..	630·97	758·7
Total number of units generated for the whole State in millions	634·63	762·6

The expansion of the Madras Grid during the three years of the Plan can be gauged from the following figures of sub-stations and lengths of lines in service, as at the end of 1950–51, and as at the end of 1953–54 :—

	As at end of 1950–51.	*As at end of* 1953–54.
(i) Number of E.H.T. Sub-stations (66 and 110 KV)	31	41
(ii) Capacity (installed) in KVA of above ..	183,600	252,000
(iii) Number of H.T. Sub-stations (33 KV and below)	29	30
(iv) Capacity (installed) in KVA of above ..	43,075	61,850
(v) Number of distribution transformers in service	1,591	2,197
(vi) Capacity of above in KVA	100,238	145,836
(vii) Length of E.H.T. and H.T. lines in miles	4,355	5,420
(viii) Length of L.T. lines in miles	3,580	5,140
(ix) Total number of consumers served ..	250,301	341,854

Rural Electrification.—Madras State leads all other States of India in rural electrification even after the partition of the State. The number of electrified villages in the State as at the end of the past four years is given below :—

1950–51	..	1,613
1951–52	..	1,820
1952–53	..	1,981
1953–54	..	2,187

The number of villages electrified in the Departmental area alone during the three years in 1951–1954 is 348, while the corresponding figure for the licensees' area is 226, making a total of 574.

Considering that the target as per the Plan was 250 villages to be electrified annually for the Composite State, the achievement in the three years for the Residuary State may be considered not unsatisfactory, in spite of the acute financial stringency in 1952–1953 and the first half of 1953–54.

The most popular use of electricity in the villages is for agriculture by means of electrical driven pumpsets for lifting water. The number of agricultural consumers in the areas served by the Government directly and by the distributing licensees taking power from the Government is given below for theyears 1950–51 and 1953–54 :—

	1950–51.	1953–54.
1. Number of agricultural pumpsets served directly by Government	11,859	17,171
2. Number of agricultural pumpsets in licensees' area	2,767	4,562
3. Total number of agricultural pumpsets ..	14,626	21,733

More than 7,000 pumpsets have been added in the three years, averaging 2,400 pumpsets added each year. The target for the Five-Year Plan for the Composite State was 3,000 pumpsets each year and the achievement of 2,400 for the Residuary State may be considered quite satisfactory.

Next to the use of electricity in agriculture in villages, is its use for rural industries. The expansion of rural industries may be seen from the following figures :—

	1950–51.	1953–54.
1. Number of rural industries	1,556	2,241
2. Connected load in KW	19,180	24,539

The rural industries comprise mostly industries for processing the village produce like tea-curing, rice-hulling, cotton-ginning, sugarcane-crushing, groundnut-decorticating, flour milling and oil *chekkus* and a few industries like fountain pen making, silk throwing, tape-weaving and woollen carpet drugget industry, etc.

Industrial Expansion.—The greatest percentage of electricity utilized among the various uses to which power is put to, is in industry, viz., 58 per cent, while this figure for other uses is as below :—

	Percentage.
Irrigation	15
Domestic	14
Commercial	6
Public-lighting	2·5
Traction	2
Miscellaneous	2·5

It is a recognized fact that electricity is indispensable for development of modern industry. The advance made in industrial expansion in the State can be assessed from the connected load in industries in the area supplied directly by the Department, which was 106,000 KW. at the end of 1950–51 and is 133,000 K.W. at the end of 1953–54.

Important among the major industries added in the three-year period of the Plan are the extensions to existing cement factories at Madukkarai and Dalmiapuram and over twenty textile mills. The number of medium and small-scale industries taking electricity has also shown rapid increase, from 3,859 with a connected load of 30,982 K.W. in 1950–51 to 5,915 with a connected load of 46,480 K.W. in 1953–54.

Progress of Schemes in the Five-Year Plan.

1. *Moyar Hydro-Electric Scheme.*—This scheme envisages the utilization of the tail waters of the Pykara Powerhouse in the Moyar Valley over a drop of 1,250 feet, nine miles lower down.

The main features of the scheme are as follows :—

Construction of a masonry diversion weir 283 feet long and 50 feet high across the Glenmorgan stream to divert the tail waters of the Pykara Power Station, construction of a channel 7,600 feet long to carry the diverted water to

an adjacent stream, and formation of a regulating reservoir of 28 million cubic feet capacity at Maravakandy, by the construction of a masonry dam 1,360 feet long with earthen bunds on either side. Water from the reservoir is taken by a flume channel to the forebay, and from there to the power-station by means of a 7-foot diameter low pressure pipeline to the surge tank at the head of the gorge and three penstocks 45 inches by 42 inches diameter running down the hill slope to the power-station. The power station is equipped with three 18,000 horse-power impulse turbines coupled to 12,000 K.W. 11 K.V. alternators. The power generated is stepped up to 110 K.V. and transmitted to Pykara and Erode through 110 K.V. double circuit transmission lines.

The main civil works have all been completed. The first generating unit came into operation in April 1952, the second in September 1952 and the third in January 1953.

The transmission lines connected with the scheme, viz., a double circuit 110 K.V. line from Moyar to Erode and another 110 K.V. double-circuit line interconnecting Pykara and Moyar power stations were completed even before the first unit came into operation.

The Major works have come to a close.

Pykara Third Stage Extensions.—The scheme comprises a second dam across the Pykara river to provide a storage of 2,000 million cubic feet, a new penstock line (laid along the existing three penstocks) and two generating units of 13,600 K.W. each at the Pykara powerhouse extended suitably.

Building masonry for the main dam structure, earth bund at right flank upstream and down-stream, retaining walls for earth bund and concreting for R.C.C. core wall on the left flank were in advanced progress during 1953–54 also. The dam is expected to be completed early in 1955.

Construction of superstructure, masonry for the powerhouse extensions and machine foundations, were completed during 1953–54. The erection of the fourth penstock line with its valves has also been completed.

The erection of the 6th and 7th generating units, as also the necessary step-up transformers and switchgear, has also been completed and the generating sets have been commissioned recently (June 1954).

The construction of the Pykara-Coimbatore third circuit 110 K.V. line for transmitting the additional power that will become available under this scheme, is in an advanced stage of progress and is expected to be completed by the end of 1954, while the Coimbatore-Madurai 110 K.V. line has been completed.

Papanasam Second Stage Extensions (including Madurai Thermal Station).—The scheme includes provision of spillway gates at the Papanasam Dam enabling additional storage in the reservoir and extension to Papanasam powerhouse by an additional generating unit of 7,000 K.W.

This work has been completed with the commissioning of the further 7,000 KW. set in July 1951.

The scheme also includes the installation of an auxiliary steam station with a total installed capacity of 14,000 K.W. near Madurai. A 4,000 K.W. turbo set with two coal fired boilers was commissioned in February 1951 under the first stage of the scheme. The third boiler associated with the unit was commissioned in 1951–52.

A second turbo set of 10,000 K.W. was commissioned at the Madurai Thermal Station in April 1953. The two 55,000 lb./hour boilers associated with the above turbo set have been also commissioned: one, on 13th March 1954 and the other, on 20th March 1954, thus completing all the works.

The following transmission lines included in the above scheme were also completed during 1953–54 :—

(i) Papanasam-Kayathar 66 KV line.

(ii) Madurai-Sivaganga 66 K V. line.

(iii) Madurai - Tirumangalam-Rajapalayam-Tenkasi 66 KV. lines.

Madras Plant Extensions.—This scheme is to augment power-supply in the Madras City by extending the Basin Bridge powerhouse to receive 60,000 KW. additional power plant in three stages.

The civil works for the first stage, viz., piling and foundation slab for the power-station, main building, office and control block; coal conveyors 1 to 5 and ash conveyors, steel work for the main building R.C. ash bunker, R.C. ash conveyor tunnel and crusher house have all been completed. The natural draught cooling tower of 15,000 gallons per minute capacity has also been completed. All the three 80,000 lb./hour boilers under the first stage have been commissioned, the first in May 1952, the second in November 1952 and the third in May 1953. The 15 M.W. turbo set under the first stage was commissioned on 14th March 1953 but it broke down during trial runs on 29th March 1953. The set was recommissioned after repairs on 14th August 1953. The first stage of the above scheme is therefore complete, except for some minor works.

Under the second stage of the above scheme, erection of one of the two 80,000 lb./hour boilers is nearing completion. Work on the erection of the foundation for the second boiler is in progress. Erection of the 15 M.W. turbo alternator under the second stage is also in progress. This set is expected to be commissioned along with the boiler No. 1 under erection soon.

Works on the third stage which involves an addition of 30 M.W. to the generating capacity, is yet to be taken up. This is covered by the Indo-U.S. agreement for Technical Aid by U.S. for which an agreement has been signed by the Government of India. This work is expected to be completed by 1957–58.

Madras - Mettur - Interconnection Scheme.—The scheme provides for the interconnection of the Mettur Hydro Station with the Madras Thermal Station by a 110 KV. transmission line tie. for interchange of power between the two stations. The scheme comprises a 110 KV. single-circuit line of 124 miles from

Singarappet to Villivakkam and a 33 KV double-circuit line from Villivakkam to Basin Bridge, with a 110/33 KV. sub-station and two 5,000 KVA. synchronous condensers at Villivakkam and additional equipment at Mettur, Erode, Singarappet, etc.

The main 110 KV transmission line was completed in 1950 itself and was operating at 66 KV. instead, permitting limited interchange of power between the Madras Thermal Station and the Mettur Hydro System.

After completing the arrangements required at various sub-stations for changing over the operation of the line to 110 KV., the circuits were changed over to 110 KV. operation. The Mettur-Erode double circuit lines were also changed over to 110 KV. operation.

The erection of one 7,500 KVA and 5,000 KVA. transformers at Villivakkam and two 5,000 KVA. synchronous condensers, was completed during 1953–54; as also the staff quarters, water-supply, etc., in the sub-stations.

The scheme is expected to be completed in all respects by the end of 1954.

Transmission Lines and Distribution.—Apart from the trunk transmission lines included in the hydro-electric or thermal projects to transmit power to the main receiving stations, a number of secondary E.H.T. and H.T. transmission lines are required for the transfer of power to the load centres, scattered all over the State. In addition, distribution lines have to be built, mostly to expand the rural electrification of this State.

The following major transmission lines were completed during the year 1953–54 :—

1. Erode-Tiruchirappalli 110 KV. line.
2. Negamam-Pollachi 66 KV. line.
3. Kancheepuram-Chingleput-Arkonam 33 KV. extensions.

Acquisition of Electrical Undertakings.—The total number of undertakings involved in the Residuary Madras State is 27 private undertakings and 27 local authorities undertakings.

Upto the end of 1951–52, three company undertakings and 20 local authorities undertakings were acquired by Government under the Madras Electricity Supply Undertakings (Acquisition) Act.

No undertakings were acquired during 1952–53 and 1953–54 due to the financial stringency and also in view of the cases filed by certain licensees in the Madras High Court questioning the validity of the Acquisition Act and the Madras High Court's decision in favour of the licensees.

The subsequent decision of the Supreme Court in favour of the licensees, when the Madras Government appealed to the Supreme Court, has necessitated the revalidation of the Acquisition Act which has been done recently.

The future programme for acquisition depends on various factors, like the condition of working of the undertaking concerned, finance available with the State Government, etc.

—"*Madras Information*"
Annual Number—January, 1955.

MADRAS

Balanced Earth Leakage Protection for Power Transformers at Coimbatore.

By R. VENKATESAN, B.E, (Hons.),
Assistant Engineer (Electrical).

Introduction.—On 19th October 1951 a major breakdown occurred at Coimbatore receiving station resulting in the failure of one of the 11 KV./22KV. 5000 KVA. power transformers. Sparkovers seem to have shorted the 5-inch gap of the arcing horn on the support insulator next to the 22 KV. bushings, and the arc seems to have persisted for some time causing severe damage to the L.T. coils of the transformer. The explosion vent of the transformer had burst open with a loud report, and the transformer oil had spurted on the gap, thus feeding the arc there. After a few seconds, the 110 KV. incoming red line O.C.B., and the bus coupler O.C.B. and the 66 KV. O.C.B. of the auto transformer No. 3 had tripped, thus isolating the section of the 110 KV. bus feeding the 22 KV. transformers. The fire near the transformer due to the oil spurt was promptly extinguished with fire extinguishers. Two of the arcing horns on yellow and blue phases were found burnt out and the transformer was found to have suffered damage in the L.T. coil on the faulty phase. The core of the transformer had flashover marks with puncture in a few stampings but the high tension windings were found intact. The transformer was repaired departmentally and put back into service on 3rd May 1952. The details of the damage and repairs done were described in Vol. VII. No. 3 of this journal. It is proposed to discuss and describe briefly in this article the remedial measures adopted to prevent such occurrences.

Remedial measures adopted.—Immediately after the occurrence, to avoid future similar bird faults, the horn gaps on the secondary side of all the 11 and 22 KV. power transformers at the receiving station were removed and re-installed beyond the kiosk on the secondary sides of the transformers. Saw-toothed bird guards were provided on the channel on which the support insulators are mounted and the jumpers between the transformer L.T. bushing and the transformer L.T. kiosk were taped and insulated at all vulnerable points. The above improvements, it is expected, may prevent bird faults similar to the one that had occurred. But the transformer could also suffer damage due to faults inside the transformer secondary coils, failure of L.T. bushings, support insulators, roof bushings of transformer kiosks, or internal faults in the transformer circuit breaker, failure of potential

or current transformers in the kiosk, etc., which are all likely to occur. It is therefore necessary to provide suitable protective devices to isolate the transformer quickly on the primary side on occurrence of such faults. A lay out of the arrangement of the 110 KV. bus and the tapping to various power transformers in Coimbatore Receiving Station is given in Fig. 1. For faults in the immediate zone of the 110 KV. incoming feeder O.C.B. and the bus coupler O.C.B., the relay settings of these O.C.Bs. had to be kept high to suit the load conditions on this section of the bus. For these settings, at the time of fault, the time of operation of the main 110 KV. circuit breakers is worked out to be about 21 seconds and for the auto transformer No. 3. O.C.B. about 3 seconds more. The above time is long enough to cause considerable damage to the transformer. Hence, various proposals were considered for providing the transformers with a sensitive protection for isolation on the E.H.T. side.

Alternative proposals considered.—(i) The best method of protection is to provide oil circuit breakers on the 110 KV. side of each transformer and to install magnetic balance relays to cover all faults on the entire zone from the transformer H.T. to the L.T. oil circuit breaker. This was considered too costly for adoption.

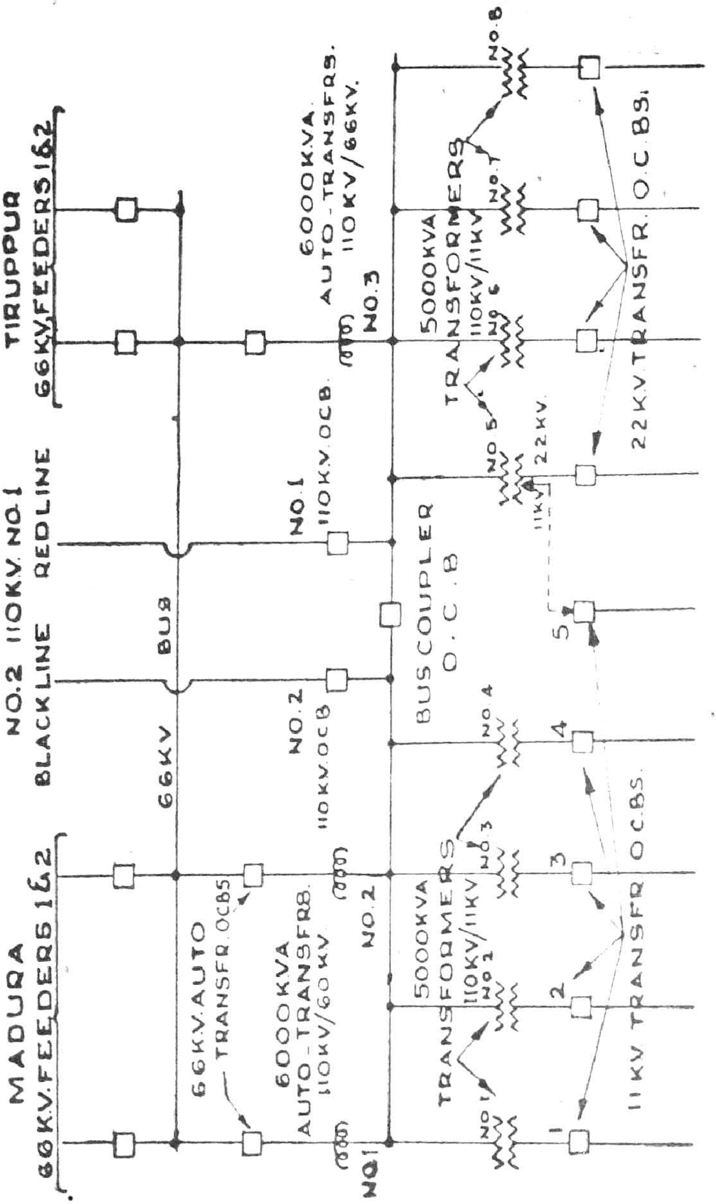
(ii) A proposal for installing one 110 KV. oil circuit breaker for each group of two transformers with plain overload and earth leakage relays was also considered but it would have taken a long time to obtain the necessary equipment and to effect the large scale modifications in the bus arrangements. Even this protection will not be very sensitive for faults on the secondary side of the transformers as the overload relay settings will have to be kept sufficiently high for catering to the full load of two transformers.

(iii) Another proposal that was considered was to operate always two transformers in parallel so that for any fault on the secondary side of one of the transformers, one or both the transformer L.T., O.C.Bs., would trip. This tripping of the O.C.B., may by means of an auxiliary relay of type A.T.A. or S.H. 28 connected to trip out the bus coupler O.C.B., and the incoming O.C.B., of that section of the bus as well as the auto transformer O.C.Bs. This proposal also was not followed up, as it would have required keeping always two transformers in parallel and mal-operations are also likely to occur for trippings of transformer O.C.Bs. for causes other than a fault in the zone proposed to be protected.

(iv) A simple balanced earth leakage protection for each of the transformers was next considered and adopted on two of the power transformers in Coimbatore receiving station and its performance has been satisfactory. It has been decided now to provide similar protection for all the other power transformers in the Department.

Balanced earth leakage or restricted earth fault protection.—This system of protection is briefly described below :—

(i) A current transformer having the same ratio and characteristics as those in the transformer



LAY OUT OF COIMBATORE RECEIVING STN.

FIG. 1.

L.T. kiosk. is erected near the transformer in a G.I. sheet kiosk, and the neutral earth connexion of the power transformer is connected through this C.T.

(ii) The secondary leads from this neutral C.T. are brought through a two core cable to the control panel, where it is connected to balance with the earth leakage circuit of the line C.T. secondaries of the transformer L.T. oil circuit breaker.

(iii) The two overload and one earth leakage relay protection, originally existing for the transformer are converted into overload on all the three phases.

(iv) The spill circuit obtained by balancing the earth leakage current in the two C.Ts., in (ii) above is connected to operate a P.B.A. type earth leakage relay with a low setting (20 per cent). If the C.T., connected are of bushing or other type with low output and impedance, it is necessary that the earth leakage relay should be of a specially sensitive type, having a low volt-ampere burden.

(v) The operation of the neutral earth leakage relay actuates a master tripping relay which trips out the 110 KV. bus coupler and the incoming O.C.Bs., as well as the 66 KV., O.C.Bs. of auto transformers on the section of 110 KV. bus feeding the transformer protected. It thus isolates the transformer completely on the E.H.T. side immediately without interruption to the other section of the bus. One common master relay is sufficient for all the transformers, tapped off each section of the 110 KV bus.

The transformers at Coimbatore receiving station are normally operated individually in sections of the 11 or 22 KV. bus and parallel operation of two transformers is resorted to during peak load hours when necessary. When two transformers in the same section of the 110 KV. bus are in parallel, tripping of the 110 KV. and 66 KV. O.C.Bs. in that section of the bus due to fault in the zone on one of the transformers in parallel will cut off supply to the other transformer also. When the spare transformer No. 5 (see Fig. 1) which is on the red line 110 KV. bus is on 11 K.V. and is in parallel with any of the 11 KV. transformers on the black line 110 KV. bus, for faults in the zone of one of the two transformers the 110 KV. and 66 KV., O.C.Bs. in the section of the faulty transformer will be tripped by the operation of the E/L. relay, but the fault will be continued to be fed from the healthy section through the 11 KV., O.C.B. of transformer No. 5 till the O/L. relay on that O.C.B. acts and trips. Hence the master tripping relay will be connected to trip the 11 KV. O.C.B. on transformer No. 5 also.

A schematic diagram of connections adopted is given in Fig. 2.

Principle of operation of the scheme.—The principle of operation of the above scheme is as follows.

Vide Fig. 3 (*a*) and Fig. 3 (*b*).

REFERENCE.

1 TRANSFORMER PRIMARY WINDING.
2 " SECONDARY "
3 NEUTRAL CURRENT TRANSFORMER RATIO X/1α.
4 TRANSFORMER L.T. OR SECY. O.C.B.
5 TRANSFORMER KIOSK OR LINE C.Ts RATIO X/1α.
6 " OVERLOAD RELAYS.
7 AMMETER SWITCH.
8 NEUTRAL EARTH LEAKAGE RELAY.
9 MASTER TRIPPING RELAY.

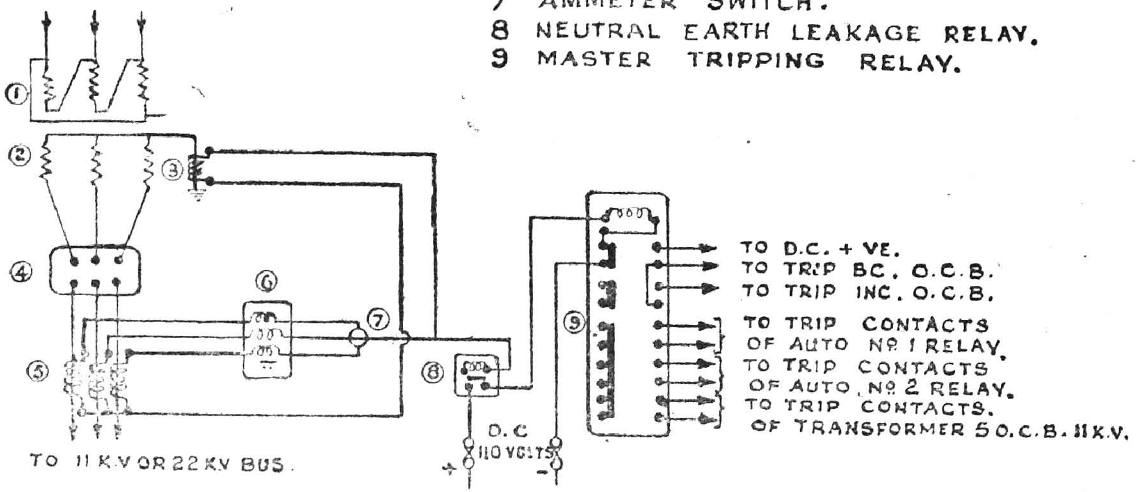
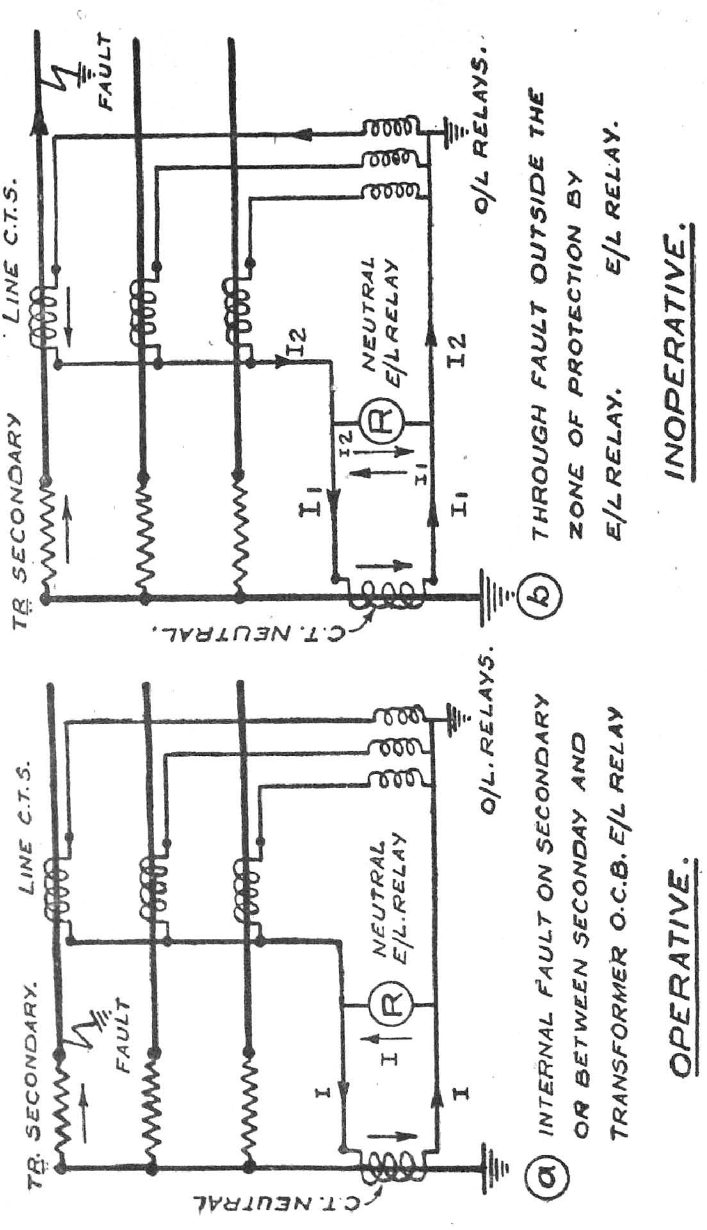


DIAGRAM OF CONNECTIONS FOR NEUTRAL E/L PROTECTION.

FIG. 2.



PRINCIPLE OF OPERATION OF BALANCED E/L PROTECTION.

FIG. 3.

For any earth fault between the transformer secondary winding and the C.T. terminals in the transformer L.T. kiosk, there will be no fault flow in the C.Ts. in the transformer kiosk but the full fault current will flow through the transformer neutral, thus causing a current from the neutral C.T. to pass through the earth leakage relay, as per Fig. 3(*a*), which operates it to trip the concerned O.C.Bs. on the primary side of the transformer. If two transformers are in parallel, the relay will be more sensitive as twice the fault current will flow through the relay circuit due to the fault being fed from both sides. When the earth fault is outside the zone beyond the transformer O.C.B. or feeder O.C.B., the earth fault current will pass through the C.T. in the transformer kiosk on the faulty phase as well as the neutral C.T. The current in the secondary of the neutral current transformer will pass through the neutral earth leakage relay from bottom to top as shown in Fig. 3 (*b*). The E/L current in the secondary of the line current transformers in the transformer kiosk will pass through the neutral E/L relay from top to bottom and the over load relay of the transformer L.T., O.C.B. Hence there will be two opposing currents in the neutral E/L relay and as the neutral C.T. and the C.Ts. in the transformer kiosk are of the same ratio, these currents will balance each other. Hence the relay will be inoperative for through faults on the transformer bus or on the feeders, even with a very low plug setting on the E/L relay.

It was feared that as the burden on the neutral C.T. and C.Ts. in the transformer kiosk are not identical it may cause appreciable spill current even for through faults and cause mal-operations. Tests injecting a phantom fault current of 200 amps through the neutral C.T. and C.T. in one phase of the transformer kiosk with all relay connections made, indicated very negligible spill currents and hence the scheme is expected to work satisfactorily.

The important point to be noted in this scheme is that the neutral current transformer should be of the same ratio and characteristics, reasonably similar, to the line current transformers in the transformer kiosk. If the line current transformers saturate at a current appreciably lower than that at which the neutral C.T. saturates or vice versa, there is risk of operation of the neutral E/L relay for through earth faults on feeders. With reasonably similar transformers we can adopt safely a plug setting of 20 per cent on the neutral E/L relay.

The only draw back of the above scheme is that it will not cater to phase faults in the zone and inter-turn faults in the transformer secondary. Phase to phase faults in the zone may be remote and even if it occurs it is quite likely to develop immediately into an earth fault which will operate the neutral E/L. relay. Inter-turn faults and phase to phase faults inside the transformer windings will have to be taken care of by Buchholz relays.

If there is an open circuit in one phase of the secondary circuit of the transformer kiosk C.Ts., there may be mal-operation of the relay due to current in the earth leakage circuit of the transformer C.Ts., due

to load current itself. Such mal-operation can be avoided by provision of the neutral E/L relay of directional induction type having two current energised electromagnets so that the relay is sensitive to fault current flow in the neutral C.T. in one direction only.

When group control 110 KV., O.C.Bs. with O/L and E/L relays which are under contemplation are installed, the neutral earth leakage relay with low setting can be connected to trip the group control O.C.B. only, and confine the interruption to two transformers only.

The balanced neutral earth leakage protection or restricted earth fault protection has been provided for the eight 5,000 KVA. transformers at Coimbatore receiving station, feeding 11 KV. and 22 KV. loads. For the three 6,000 KVA auto transformers in service, this type of protection is not practicable as the primary and secondary windings are common. Provision of transformer tank earth leakage protection for the auto transformers for winding faults to earth only has been proposed.

Conclusion.

Summarising.—(1) The restricted earth fault protection described above is applicable to all Delta/Star or Star/Star power transformers with secondary neutral earthed, and isolation on the primary side is possible only where primary group control or individual O.C.Bs. are available.

(2) This scheme of protection will protect the transformer against any earth fault in the zone from the secondary windings to the line C.Ts. in the transformer L.T. kiosk and will be inoperative for through feeder faults.

(3) A very low plug setting independent of load current and relay settings of other O.C.Bs. is possible and hence the relay is sensitive.

(4) For proper operation of the relay it is essential that the neutral current transformer and the line current transformer in the transformer L.T. kiosk are of the same ratio and have characteristics reasonably similar.

(5) This system of protection can be extended to existing power transformers which have O.C.Bs. with relay protection on the L.T. side and individual or group control O.C.B. on the H.T. side with a small additional cost. The following additional equipments only are required:

(i) A current transformer, of the same ratio and characteristics as the current transformers in the transformer L.T. kiosk, which can be installed out-door.

(ii) A sensitive earth leakage relay of low volt-ampere burden with low plug settings available. A directional induction type relay with two current energised electromagnet is preferable.

(iii) Necessary cables to extend the neutral C.T. secondary to the panel board in control room.

(iv) Where more than one O.C.B. is to be tripped to isolate the transformer completely, an auxiliary D.C. master tripping relay with required number of closing contacts is required.

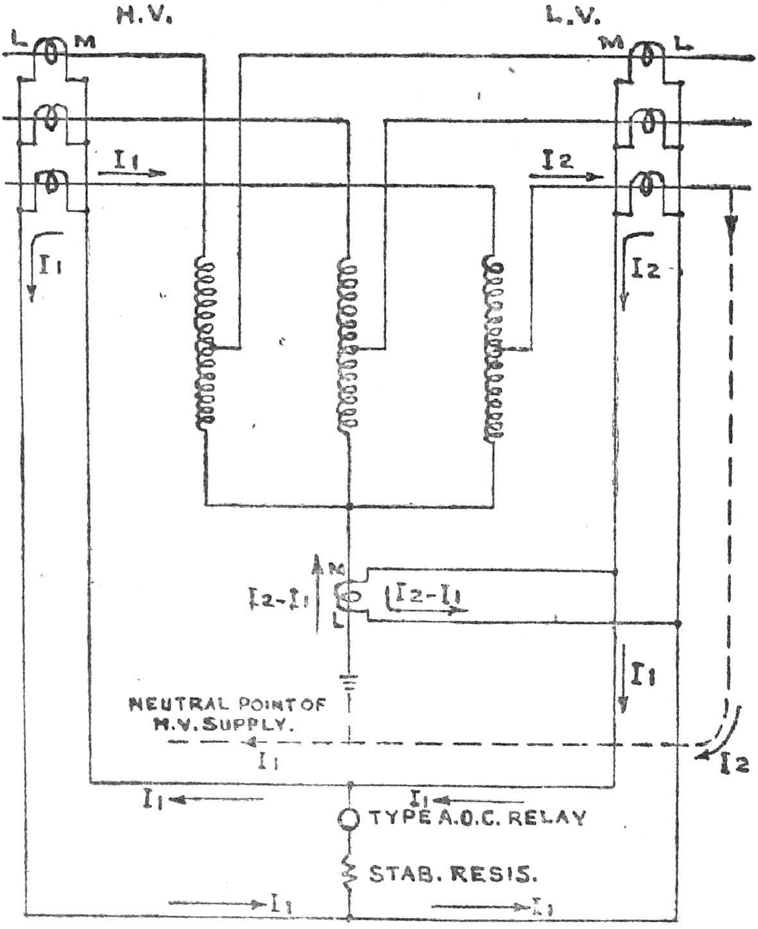
[A Note on Sri R. Venkatesan's article by the Superintending Engineer, Technical (Electrical).]

The author has indicated that for the 6 MVA Autos, the Scheme of balanced earth leakage protection or 'Restricted earth fault protection' as it is popularly known, is not applicable "as the primary and secondary windings are common" and that provision of transformer tank earth leakage protection for the auto-transformers for winding faults to earth has therefore been proposed.

The fact that in auto transformers the primary and secondary windings are common does not impose any limitation to the scope of application of the principle of restricted earth fault protection to such units. The details, such as number and location of current transformers would of course differ. The scheme has actually been decided upon for the 12 MVA autos to be installed at Madurai and also proposed to be adopted for the 12 MVA autos for Tiruchirappalli and Villupuram. The transformer tank earth leakage protection, referred to by the author, was also considered as an alternative, and after detailed discussion, the restricted earth fault scheme was preferred as the better and more reliable scheme of protection. The principle of operation of the two schemes as applied to autos and their relative advantages are briefly dealt with below as it is considered it may be of interest in the context and also by way of supplementing the main article.

Restricted earth fault scheme.—The principle of operation of restricted earth fault protection as proposed for the 12 MVA auto at Madurai (and applicable to all autos in general) is shown in Fig. 1. There is a set of three line C.Ts. on the L.V. side and another set of three C.Ts. on the H.V. side, each set connected as a zero sequence net work, and in addition a C.T. is installed in the neutral circuit of the auto. All the C.Ts. are of the same ratio. As the neutral circuit in an auto is common both for primary and secondary sides the current flowing in the neutral for any fault is the difference of the zero sequence currents in the primary and secondary sides. The distribution of fault currents in the circuits for an internal earth fault on the secondary side, indicating stability of operation of the relay is also indicated in Fig. 1. The secondary zero sequence current I_2 less the neutral current $(I_1—I_2)$ is balanced against the zero sequence current I_1 from the primary C.Ts. The relay is connected in the spill circuit. For any earth fault between the location of line C.Ts. on the H.V. and L.V. sides there is unbalance and the relay operates, i.e., the zone covered by the relay is restricted to the zone between location of C.Ts. on H.V. and L.V. sides. As invariably only a single breaker is provided in the Department for a bank of autos, for group control on the H.V. side, the C.Ts. for retricted earth fault protection are provided in the auto transformer bushings on the H.V. side. On the L.V. side, the C.Ts. are conveniently located in the respective O.C.B.

ALL C.T's THE SAME RATIO



FAULT CURRENTS UNDER AN EXTERNAL EARTH FAULT INDICATING STABILITY OF OPERATION — — — →

RESTRICTED E/F PROTECTION OF AN AUTO-TRANSFORMER (COVERING BOTH PRIMARY & SECONDARY WINDINGS)

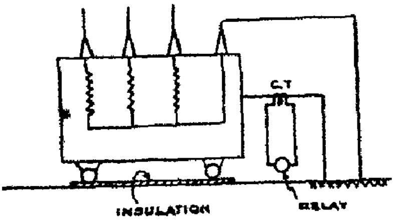
FIG. 1

FROM G.E. CO., LTD., DRG. No. 2056038.

bushings. As, at Madurai, there are power sources on both the 110 and 66 KV sides, the operation of the earth fault relay is arranged to trip out the 110 KV auto transformer group control breaker and also the individual 66 K.V. auto transformer control O.C.Bs. of all units by an auxiliary tripping relay.

This scheme involving as it does seven C.Ts. may appear more complicated than even the Merz Price protection which requires only six C.Ts. and covers both phase to phase and phase to earth faults. The merz price scheme is however not quite suited in the present case as the units are provided with on-load taps ranging up to + 9 per cent and the currents on H.V. and L.V. sides will not always balance. Hence low current settings cannot be adopted. In the restricted earth fault scheme, only the zero sequence currents are balanced and the operation of the relay is unaffected by load currents or magnetizing current.

Tank leakage protection.—This scheme otherwise known as the "Howard system of protection" consists of a C.T. connected in the



TANK EARTH LEAKAGE PROTECTION.
FIG 2

tank earth circuit with a relay responsive to the actual current flowing from the transformer tank to the earth in the event of an internal earth fault, the tank being lightly insulated from the earth (Fig. 2). The scheme appears to be mostly in use in French power system, and in conjunction with the Buchholz device is considered as a reliable and simple form of protection. The reliability of the scheme depends, on the whole or at any rate the greater part, of the current in the event of an internal earth fault passing through the primary of the C.T. in the tank earth connection. This will require the insulation of the tank as a whole effectively from earth so as to reduce the currents flowing through other parallel paths to a minimum. The tank insulation to earth should be obtained by ensuring that plinth rails are clear of any adjacent metal work and that the rail bolts are clear of steel re-inforcing rods. C.T. in the tank earth connection should be of the bar primary type to obtain secure earthing of tank. The lead sheath of all cables to the transformer tap changer equipment, Buchholz relay, temperature indicator, etc., should all be insulated from the tank with a cable gland insulation suitable for 4 KV to earth for one min. with-stand test. The lead from neutral of auto to earth should also be taken clear of the tank and connected to separate earth pit.

Relative merits.—The restricted earth fault scheme of protection is a more comprehensive scheme adopted widely in Canada, U.S., U.K. and Sweden. It may be considered by some as complicated

and costlier involving as it does seven C.Ts. paralleled on a single pole relay. In the case of transformer with large rating, the extra cost on C.Ts. is warranted, providing as it does a more satisfactory scheme of protection. The introduction of C.Ts. in transformer bushings though widely adopted is considered not desirable by some as for any breakdown of C.Ts. the whole unit is rendered unfit for use.

The tank earth leakage protection appears apparently quite simple. Actually it involves a number of complications in installation and requires elaborate precautions to ensure the insulation of tank from earth. As stated earlier, the lead from neutral will have to be taken without touching the tank and connected to separate earth. Lead sheaths of all cables are to be insulated. The stipulation in I.E. rules that the tank has to be earthed to two independent earths cannot be complied with. Further in the autos with on load tap changing mechanism, an A.C. motor is provided on one side on the tank and any fault in the motor circuit will result in a flow of current to earth through the protective C.T. and cause false tripping of 110 and 66 K.V. breakers and interruption to supply. This defect can however be overcome by providing a larger time setting for the tank earth leakage relay to ensure that for faults in L.T. circuit the motor cut-outs operate first. But this places a serious restriction on the scope of the Howard System of protection as it is not possible to have a low time setting and ensure quick clearing of faults. Considering the above disadvantages, the restricted earth fault scheme was preferred as a better and more reliable scheme of protection.

Testing Kilovar R.S.S. Meters at the Standards Laboratory.

By S. RAMAN, B.E. (Hons.),
Assistant Engineer (Electrical).

Testing of Kilovar R.S.S. meters is an important item of testing work done by the Standards Laboratory. This article deals briefly with the procedure adopted in this testing at the Standards Laboratory.

Measurement with two standard wattmeters.—A 3-phase 3 wire KWH R.S.S. meter has two elements: the blue element, carrying the blue phase current and connected to potential BY; and the red element carrying red phase current and connected to potential RY. In the calibration on the test table at the Laboratory, each of these elements

is represented by a standard wattmeter, connected to the same potentials and currents as the elements of the R.S.S. meter under test.

When a 3 phase 3 wire reactive power R.S.S. meter is to be calibrated, since in each of its elements, there is an effective internal 90 degrees shift between the potential and series fluxes, how far this shift can be represented by wattmeters connected to the circuit becomes a matter for study. It is, of course, feasible to use two wattmeters only as for the calibration of KWH. R.S.S. meter, with a change in the polarity and sequence of currents, to measure the reactive power, provided the voltages and currents are correctly balanced. There are two possible connections to the wattmeters for measurement of reactive power under balanced conditions:

1. *Change of polarity of current to red element wattmeter.*—The blue element wattmeter is connected to potential BY and current B: it records EI Cos $(30-\theta)$, where E is the phase voltage: I, the current and Cos θ, the load power factor.

The red element wattmeter is connected to potential RY and current R reversed; and it records minus EI Cos $(30-\theta)$.

The total record by the two wattmeters is EI Sin θ which is proportional to the true reactive power in the circuit viz., $\sqrt{3}$ EI Sin θ—vide Figure 1.

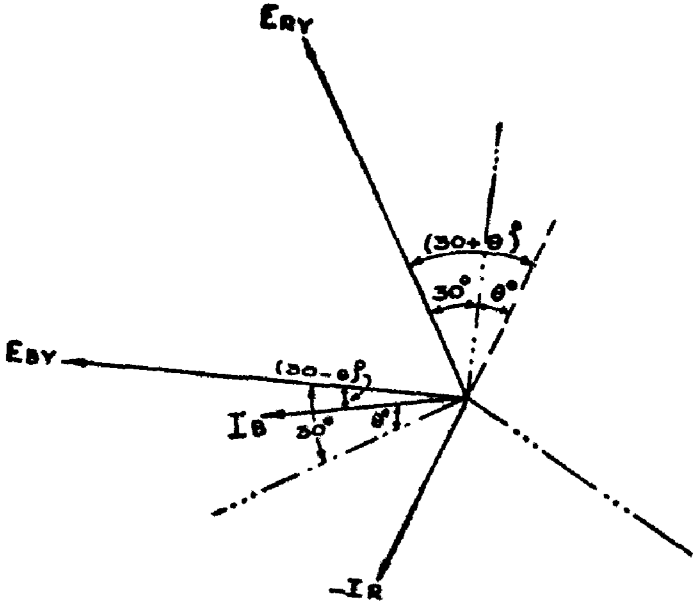


FIGURE 1.

At zerolag power factor, the blue element wattmeter records ½ EI: red element wattmeter records ½ EI: and total record is EI.

At 30° lag power factor, the blue element wattmeter records EI: red element wattmeter records minus ½ EI; and total record is ½ EI. As the red element wattmeter records minus EI, the current polarity would have to be reversed to get a reading in the wattmeter; and the reading taken as negative.

The wattmeters, individually, are connected similar to measurement of power in the circuit or as for testing of KWH. R.S.S. meters; the difference of the readings being taken to represent reactive power, and summation, active power in the circuit.

This connection to the two wattmeters may be called 'KWH' connexion.

2. *Change of sequence and polarity of current.*—In this arrangement, the blue element wattmeter is connected to potential BY and current R reversed; the red element wattmeter is connected to potential BY and current B.

Each wattmeter then records EI Sin θ: and total records is 2 EI Sin θ as against the true reactive power of $\sqrt{3}$ EI Sin θ—vide Figure 2.

This connexion may be called the cross current connexion as the blue element wattmeter gets the red current and the red element wattmeter, the blue phase current.

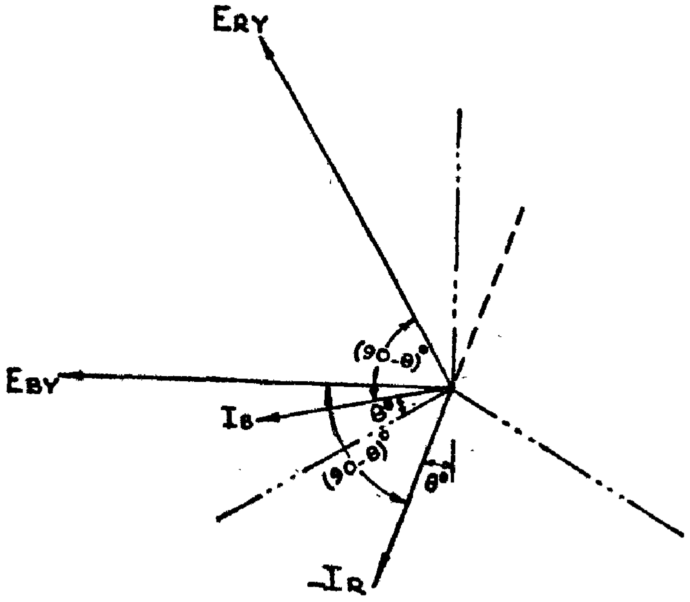


FIGURE 2.

At zero power factor, each wattmeter records EI and the total record is 2 EI.

At 30° lag power factor each element records ½ EI and the total record is EI.

Unbalance in currents.—The potential supply to the test table is taken off a potential sine wave alternator, and is therefore balanced. The current supply is similarly taken off a current alternator and while even here the voltage of supply would be balanced, it may not be strictly correct to assume that the currents are balanced throughout the range of loads, used for the testing, due to the introduction of loading and current transformers in the circuit and also due to the fact that the wattmeter reading is a function not only of the values of current and voltage but also of the phase angle between the voltage and current ; and a shift in the angle is liable to get compensated by a change in the value of current.

It is desirable, therefore, to assess the effect of a small unbalance in the currents on the accuracy of testing the reactive R.S.S. meters, with two wattmeters only.

The following forms of unbalances may be considered : —

1. Increase in the values of the red and blue currents by 0·5 per cent each.

2. Increase in the value of red current by 0·5 per cent : and decrease in the value of blue current by 0·5 per cent.

3. A shift in the phase angle of both currents by 30 minutes lag.

4. A shift in the red current by 30 minutes lag : and in the blue current by 30 minutes lead.

A change in the value of one current only, or a change in both by different extents can be considered as a combination of (1) and (2) : and similarly, a shift in the phase angle of one current only or shift in both by different extents can be considered as a combination of both (3) and (4).

Errors in the 'KWH' connection method.—The table below gives the apparent errors in a reactive R.S.S. meter due to a small unbalance in currents when the wattmeters are connected in the 'KWH' connection.

Details of change.	*Apparent R.S.S. error at zero power factor.*	*Apparent R.S.S. error at 30° lag power factor.*
1 R and B increase 0·5 per cent	Nil.	Nil.
2 R + 0·5 per cent : B − 0·5 per cent ..	Nil.	+ 2·0 per cent.
3 R and B lag 30 minutes	Nil.	Nil.
4 R lags 30 minutes : B leads 30 minutes ..	— 2·0 per cent.	— 2·0 per cent.

To illustrate how the apparent R.S.S. errors are arrived at, a sample calculation for item (4), 30 degrees lag power factor, is shown below.

Assume a voltage of 100 volts: and a load of 5 amps. The wattmeter records with and without the unbalance of currents are as under:

Wattmeter.	*Record under balanced load.* *Watts.*	*Record under unbalanced load.* *Watts.*
Blue element ..	500	500
Red element ..	− 250	− 246·25
Total ..	250	253·75

The total record by the two wattmeters is therefore increased by 1·5 per cent.

Details of change.

	Apparent R.S.S. error at zero power factor.	*Apparent R.S.S. error at 30° lag power factor.*
1 R and B increase 0·5 per cent	Nil.	Nil.
2 R + 0·5 per cent; B − 0·5 per cent ..	Nil.	+ 0·5 per cent.
3 R and B lag 30 minutes	Nil.	Nil.
4 R lags 30 minutes; B leads 30 minutes ..	— 0·5 per cent.	− 0·5 per cent.

A sample calculation is shown below again for item (4) 30 degrees lag power factor.

The wattmeter records with and without the unbalance of currents are as under:

Wattmeter.	*Record under balanced load.* *Watts.*	*Record under unbalanced load.* *Watts.*
Blue element ..	250	253·75
Red element ..	250	246·25
Total ..	500	500·00

The effect on the reactive power in the circuit under unbalance of currents is given below:

Element of reactive meter.	*Record under balanced load.* *Watts.*	*Record under unbalanced load.* *Watts.*
Red element ..	500	502·5
Blue element ..	..	− 5
Total ..	500	497·5

The reactive power in the circuit is therefore less by 0·5 per cent. Hence the reactive R.S.S. meter appears to be 2 per cent slow with respect to the wattmeter records: and the apparent R.S.S. error is minus 2 per cent.

Errors in the cross connection method.—The table below gives the apparent errors in a reactive R.S.S. meter due to a small unbalance in the currents when the wattmeters are connected in the cross current connection.

The total record by the two wattmeters is neither increased nor decreased by the unbalance. But the reactive power in the circuit as a result of unbalance is less by 0·5 per cent. Hence the reactive R.S.S. meter appears to be 0·5 per cent slow, with respect to the wattmeter records.

Comparison of the two methods.—On a study of the errors arising in the two methods of connection it is seen that,

(1) Both methods give no error at zero power factor for changes in the values of current provided the angle between the currents is 120 degrees.

(2) Both methods give no error at 30 degrees lag power factor, only if the loads are balanced.

(3) Both methods give errors for unequal changes in current values and unequal shifts in phase angle of currents. The errors arising in the "KWH" connection are considerably more than the errors in the "cross current" connection: and between the two methods of connection the "cross connection" is to be preferred, because of the lesser errors involved therein.

(4) The errors arising in the 'KWH' method are exactly four times the errors arising in the "cross connection" method: and hence a combination of the two methods may result in correct representation of reactive power.

Four wattmeter method.—At the Laboratory, four wattmeters are used in the testing of kilovar R.S.S, meters, connected as under:

Wattmeter.	*Connection of potential.*	*Connection of current.*
W1	YB	R
W2	RY	B
W3	RB	R
W4	RB	B

It can be proved that for any kind of unbalance in the currents, the summation of wattmeter readings represents true reactive power in the circuit—vide Figure 3.

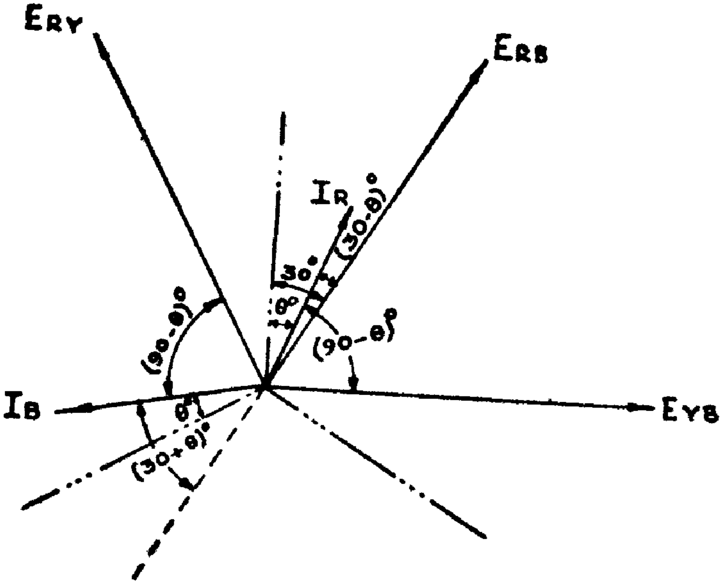


FIG. 3.

Item (4) of unbalance may be taken up for verification.

The wattmeter records with and without the unbalance of currents are given below :

Wattmeter.	*Record under balanced load.*	*Record under unbalanced load.*
	Watts.	*Watts.*
W1	250	253·75
W2	250	246·25
W3	500	500
W4	− 250	− 253·75
Total ..	750	746·25

Record under unbalanced connection is 0·5 per cent less than the record under balanced load condition. But due to the unbalance the reactive power in the circuit is actually less by 0·5 per cent. Hence the summation of the wattmeter records represents correctly the actual reactive power in the circuit.

The four wattmeter method is therefore a technically correct method of measurement of reactive power in the circuit.

It would be seen that the wattmeters represent a combination of the cross current connection and the 'KWH' connection of wattmeters. At zero lag power factor of load, the power factors of the two wattmeters of the former are both unity and for the latter the power factors are 60 degrees lead and 60 degrees lag. In the four wattmeter method the wattmeters W1, W2, W3, W4 have power factors respectively of unity, unity, 60 degrees lag and 60 degrees lead, for zero power factor of load.

With only two currents for the four wattmeters, it would be feasible to keep the two wattmeter readings W1, W2 constant. Wattmeters W3, W4 are found to remain steady, when once the readings have been set at particular values.

Just as a kilovar R.S.S. meter, can be tested by two wattmeters, connected in 'KWH' connection or in "cross current" connection, a reactive KWH commercial meter, either independent or as incorporated in a trivector meter, can be tested in the absence of a kilovar R.S.S. by using a 'KWH.' R.S.S. meter with the elements connected up either (1) in the KWH connection with polarity of red current reversed, or (2) in the cross current connection.

KWH. R.S.S. with the cross current connection is normally used in preference to the KWH. connection as (1) the errors involved in the former are substantially less than the errors of the latter, and (2) the speed of the R.S.S. in the former connection is double the speed in the latter connection and calibration therefore is quicker with cross current connection.

For tests done at meter testing laboratory, due to proximity of transformer station, the voltages are balanced. For tests done at site, the voltage supply is taken from the potential transformer installed at the premises, for power measurement, to the H.T. testing kit and here also the voltages are closely balanced ; currents are balanced by adjustments made in the testing kit. The unbalance that still remains gives but a small percentage of error in the testing of the kilovar meter.

The exact error will depend on the extent of actual unbalance, but as the total effect of a one per cent change in current and a one degree shift in phase angle is only just one per cent error at the most, adjustments done on the meter may be quite good for all practical purposes.

Operations and Maintenance Problems—Fatal Accidents from Earth Wires.

By N. B. VASUDEVAN.

An earth wire in an installation is intended to protect persons from getting electric shocks in cases of leakage in the installation resulting in any equipment getting electrically charged. It, however, sometimes happens that the earth wire which is meant to provide the necessary safety becomes itself the cause of serious or even fatal accidents. Recently there were two such accidents due to contact with earth wires of radio sets. In both cases the consumer's earths were very poor. The details of the accidents are given below :

On 27th July 1954, one Sri T. S. Muthukrishna Iyer, aged about 78, Salem, was working in his garden clearing weeds, etc. While doing this he seems to have caught hold of the earth wire of the radio set connected to an earth pipe. This earth wire was alive due to leakage from the radio set. The ground was wet due to rains the previous night. The gentleman seems to have received a severe shock from the earth wire and he fell down unconscious. He was found lying on the ground about half an hour later with the live wire still in his hand and the top of the earth pipe which had got broken due to complete rusting. A lady who saw him in that condition seems to have also got a shock when she touched him. She, however, raised an alarm and later the main switch was swiched off and the gentleman removed from the spot. He was found dead. The earth pipe in this case was found to be very rusty at the point of connection to the earth wire and that is why it had broken there.

The second accident occurred at Madras on 31st August 1954. When one Sri S. Gopal, a young man, was testing a radio set in the first floor of his residence. He put in the plug and directed his servant to go down to find out if the earth wire was giving a shock. The servant touched the earth wire, got a shock and could not let go and shouted. Sri S. Gopal, instead of immediately removing the plug and isolating the

set, rushed down and pulled away the servant who fell down unconscious; but while extricating the servant Sri S. Gopal got entangled in the bare earth wire and also fell down unconscious. The servant boy, when he recovered some 10 minutes later saw Sri Gopal with the earth wire in his hand. Later the gardener came and switched off the mains, but by then, about half an hour, had elapsed. Sri Gopal was rushed to the General Hospital, where it was stated that he had died some time back.

The earth, in this case, is a 1¼ inch G.I. pipe about 2 feet in length, driven into the ground only one foot. The earth wire was found twisted round it.

There is a misnomer among the general public that mere contact with earth constitutes a proper and safe earth. The writer knows of a case where a tenant living in a top flat considered he had a perfect earth by connecting the earth wire of his radio set to the earth in a flower pot in his flat. He was watering the pot daily and with an artistic taste he had put the pot on a neat wooden teapoy. Some consumers use old corroded pipes for earth and they bury these a foot or two in their lawn and connect their earth wire to it thinking that it ensures safety.

It is well known that even some of the well-made earths of electric supply undertakings, containing pipes driven 5 or 6 feet or more in ground, give sometimes poor earth. It is therefore hardly possible to always expect a consumer to instal and maintain a very good earth in their installations. The only alternative to ensure safety is to interconnect the consumer's earth with the earth system of the supply undertakings. Also, the earth wire of radio sets, where accessible, could be of insulated wire. Similarly, in view of certain fatal accidents due to electric shock from aerials of radios, the aerial leads to the radio set could also be of insulated wire, wherever accessible. It seems essential to correctly advise consumers in the matter to prevent further accidents.

Progress during quarter ending 30th September 1954.

Construction Branch.

Pykara Plant Extensions III Stage.—Masonry work in the main dam in the overflow section was continued. Masonry for the retaining wall in the right flank D.S. 343 to 463 was completed. Buildings rivetment between D.S. 343 to 400 and 400 to 430 was completed up to 705·5 level and 698·0 respectively. Progress on the earthen embankment was hampered by monsoon.

Madurai Thermal Scheme.—The servicing of the 10 M.W: set by Hitachi engineers was completed and tests were progressing.

Transmission lines and sub-stations—Salem sub-station.—Erection of structure was completed and the sub-station extension was taken over on 30th May 1954 from the contractors.

South Kanara Scheme.—In the Hulika-Mangalore section, jungle clearance, check-survey and excavation and stub-setting were completed. Erection of towers (98 per cent), stringing of conductors (31 per cent), and earth wire (34 per cent), hoisting of insulators (72 per cent), and earthing of towers (50 per cent) were in progress.

Pykara-Coimbatore-Madurai 110 KV line.—Works in respect of Coimbatore-Madurai 110 KV line were completed. Under the Pykara-Coimbatore 110 KV line, all works in the plains section were completed. In the hills section, tree clearance, tower erection, painting, and earthing of towers, and stringing of earth wire and conductors were continued.

Mettur Workshop Expansion Scheme.—Erection of machinery was continued.

Madras Plant Extensions.—Under the II stage extensions, erection of the No. 1 boiler was nearing completion. Erection of the 15 MW turbo-alternator, No. 1, was completed during the quarter and the machine was run on trial in 1954. Certain defects noticed during trial run are being rectified.

Madras-Mettur Interconnection Scheme.—The commissioning of the III and IV auto transformers at Singarappet and the changeover of the 2nd circuit from Mettur to Singarappet also to 110 KV were done.

Operating Systems.

Hydro Systems.

Generation.—The station peak load, system peak load and the units generated during the quarter were as follows :—

Name of system/station.	*Station peak load in MW.*	*Units generated in millions.*	*System peak load in MW.*
Pykara	65·0	81·85	65·20
Moyar	37·0	33·42	..
Mettur	43·6	62·26	56·2
Papanasam	28·0	28·57	28·0
Madurai (thermal)	10·0	1·03	..
Udipi	194 KW	0·13	..
Karkala	38·5 KW	0·02	..

Tha following services were connected during the quarter:—

	Agricultural.	Industrial.	Domestic.
Pykara System	137	11	1,133
Mettur System	172	19	489
Papanasam System	114	15	1,462

The Mettur outdoor E.H.T. lines—section operating at 66 KV for feeding Mettur-Singarappet 2nd circuit and Villupuram loads was changed over to 110 KV.

The overhauling of 10 M.W. set at Madurai Thermal Station was completed.

The total outturn of the Mettur workshops during the quarter was Rs. 5·23 lakhs.

At Ambur sub-station, the 1,250 KVA. MV. transformer was commissioned into service on 22nd August 1954 in the place of a 500 KVA unit.

At Salem sub-station, the third 2,500 KVA transformer was comissioned into service on 30th August 1954.

At Singarappet sub-station, the third and fourth 6,000 KVA autos were commissioned on 10th September 1954, and 25th September 1954, respectively and the Mettur-Singarappet line No. 2 was changed over from 66 KV to 110 KV operation thus completing the entire 110 KV change over.

At Pasumalai sub-station a new 5,000 KVA transformer was commissoned on 11th September 1954 and a 12,500 KVA transformer was also being got ready for commissioning.

Thermal system.

Madras Electricity system.

The station peak load, units generated and the system peak load were as follows:—

Name of station.	Station peak load in MW.	Units generated in millions.	System peak load in MW.
'A' Station ..	21·4	16·122	34·8
'B' Station ..	13·2	5·178	
'C' Station ..	1·2	0·10	

A total of 337 D.C. services were changed over to A.C. with a connected load of 120·3 KW.

Eighty-eight agricultural services, 59 industrial services and 965 domestic services were connected during the quarter.

The generation at Madras was kept reduced by taking advantage of the substantial relief afforded by the hydro systems and availing the irrigation discharge at Mettur.

The 15 M.W. turbo-alternator was shut down from 19th August 1954 to 17th September 1954 and again from 29th September 1954, for certain major maintenance works.

Accounts Branch.

The Department earned a revenue of Rs. 141·53 lakhs during this quarter and the working expenses including suspense amounted to Rs. 150·78 lakhs which includes annual contribution to the reserves amounting to Rs. 82·87 lakhs. The capital expenditure during the quarter amounted to Rs. 22·13 lakhs.

The following loan contributions were received in the various systems to end of August 1954.

Name of system.	*Rs. in lakhs.*
1 Pykara	9·10
2 Mettur	3·35
3 Papanasam	2·88
4 Madras	13·27

Technical Branch.

Electrical.—The following were some of the more important works attended to during the quarter :—

1. Tenders received against Singarappet-Villupuram and Singarappet-Vellore extensions were analysed.

2. Administrative sanction of Government was received for the Theni-Sembatti 110 KV line.

3. Under the Madras plant extensions, specification for the third stage plant and machinery was issued by the Director-General, Supplies and Disposals, New Delhi.

4. Preliminary scheme report for the Neiveli Thermal Scheme was prepared.

5. Specifications for A.C.S.R. conductors, galvanized stay wire, etc., were issued during the quarter.

6. A conference was held at Bangalore on 25th September 1954, for discussing the relative merits of Kundah and Barapole hydro-electric schemes. Madras was represented by the Chief Engineer for Electricity, Consulting Engineer to Government (Electrical) and Consulting Engineer to Government (Civil).

7. Designs of power stations, transmission lines and sub-stations were finalised. Specifications for the outdoor-yard generating plant and switchgear power transformer for the Periyar hydro-electric scheme were finalised.

8. The scheme report of auxiliary power-house at Thambraparni Dam was prepared and sent to Government. The preparation of the scheme report of Pykara Dam auxiliary power-house was nearing completion.

9. All the exhibition models were erected in the Museum and all works except water effects and lighting arrangements were completed. Sri C. Subramaniam, Minister for Finance, visited the Museum on 16th September 1954.

10. Network analyser studies at Bangalore were completed and the detailed report was prepared.

Civil.—The following were some of the more important works attended to during the quarter :—

1. Contract was awarded to Messrs. Carlick & Co., for replacing of venturimeters of 1 and 2 pipe lines of Pykara Penstocks.

2. Coramandel Engineering Company's officer to construct pressure piles was accepted for the Madras Plant Extensions, II stage, for foundation of boiler No. 5.

3. Foundations for steel structures at Singarappet, Pykara, Thudalur, Hiriadka, etc., were finalised.

4. Under the Periyar hydro-electric scheme, designs for power tunnel, surge shaft and penstocks were prepared.

5. Rainfall and run off statements, duration curves, etc., were prepared for the Kumbar-Amaravathy hydro-electric scheme.

6. An estimate for detailed investigation of Coonoor-Karteri hydro-electric scheme was prepared and submitted to Government for sanction.

7. Collection and compilation of rainfall and run off of various basins in the State were continued. The number of rainfall stations rose to 391 during the quarter.

8. Contract for the construction of a measuring weir across Naduvattam was awarded.

9. Proposals for the installation of rainfall stations in Coonoor, Karteri, Kallarpalayam, etc., were sanctioned.

10. Construction of a measuring weir across upper Bhavani was completed and work on the weir across Punnapuzha was progressing.

11. Estimates for the construction of measuring weirs across Coonoor and Karteri and installation of rainfall station in Karteri basin were prepared.

12. Site surveys for the construction of measuring weirs across Alladaballa, Killinjadahalla and Kallarpallam as also installation of rainfall stations were over.

13. At Palniar, reconnaissance work in Kudirai Air basin surveys in Kondanavar basin, preliminary reconnaissance for the alternative weir sites and proposed rainfall stations in Amaravathy and Thenar basins were done.

WORLD POWER PRODUCTION

World production of power from the main sources of supply.

Year.	Coal and Lignite, millions of metric tons.	Crude Petroleum, millions of metric tons.	Natural gas, 1,000 millions of cubic metres.	Electric Power, 1,000 million KWH. Total.	Electric Power, 1,000 million KWH. Hydro-electric.
1913	1,256·1	53·7	18·1	..	40
1938	1,300·5	280·7	78·5	460·6	172·9
1946	1,290·9	376·8	132·4	644·0	232·0
1950	1,551·3	524	212·2	951·4	332·7
1951	1,640·3	592	239·7	1,060·5	368
1952	1,608·3	618·1	284·2	1,134·0	397·0

World production of power from the main sources, given in Coal Equivalent in Millions of Metric Tons.

Year.	Coal and Lignite.	Crude Petroleum.	Natural gas.	Hydro-electric.	Total.
1913	1,256·1	80·1	27·0	32·0	1,395·2
1938	1,300·5	418·9	117·2	138·3	1,974·9
1946	1,290·9	562·4	197·6	185·6	2,236·5
1950	1,551·3	782·1	316·7	266·2	2,916·3
1951	1,640·3	877·1	357·9	294·5	3,169·8
1952	1,608·3	922·5	425·4	317·1	3,273·3
		In Percentages.			
1938	65·9	21·2	5·9	7	100
1952	49·1	28·2	13·0	9·7	100

Annual rate of increase in the World production of power.

Period.	Coal and Lignite.	Crude Petroleum.	Natural gas.	Hydro-electric.	Total.
	PER CENT.	PER CENT.	PER CENT.	PER CENT.	PER CENT.
1929–1938 ..	—0·75	3·50	3·50	5·00	0·50
1938–1946 ..	—0·10	3·38	6·75	3·75	1·60
1946–1952 ..	3·75	8·60	13·60	9·30	6·56
1920–1952 ..	0·82	5·88	8·20	6·35	2·55

Countries.	Per cent.	Countries.	Per cent.
Austria	7·3	U.S.S.R. (1921–38). ..	8·0
France	5·7	U.S.A.	8·6
West Germany (1947–52).	171	Canada	6·3
East Germany (1947–52).	9·6	Mexico	5·7
United Kingdom	7·1	Argentina	5·2
Italy	5·1	Brazil	7·5
Norway	4·7	Chile	9·9
Portugal	8·6	Columbia	10·3
Spain	8·4	Venezuela	14·5
Sweden	6·9	India	8·7
Switzerland	4·5	Australia	7·3
Europe (without U.S. S.R.)	4·8	New Zealand	6·8

Production of Hydro-Electric power in 1,000 Millions of KWH for the year 1952.

Europe	136	North America	175
U.S.S.R.	13	South America	13
Asia	52·5	Australia	5·7
Africa	1·8		
		Total ...	397·0

Realistic Estimate of the World's Hydro-Electric power as at the end of 1952.

Countries.	Energy in KWH 10^6 p.a. — Ultimate developable.	Energy in KWH 10^6 p.a. — Developed to end of 1952.	Power in MW. — Ultimate developable.	Power in MW. — Developed to end of 1952.	Percentage developed.
North America.*	807,500	175,000	161,500	32,500	20
Europe (excluding Russia).*	491,100	133,646	98,050	29,625	30
Russia in Europe (say) ..	90,000	20,000	20,000	5,000	25
Siberia and other U.S.S.R.(say).	111,000	13,200	25,000	3,600	12
Asia (excluding U.S.S.R. and China).	454,000	44,300	88,000	10,280	11·7
China	250,000	2,500	50,000	500	1
Australia *	24,500	3,000	5,560	605	10·8
Papua and New Guinea ..	66,000	450	15,000	10	0·1
New Zealand *	40,000	3,400	8,000	800	10
Africa	450,000	1,320	100,000	300	0·3
East Indies, Philippines, Pacific Islands, etc. (say).	66,000	4,500	15,000	1,000	6·7
South America (say)	450,000	27,000	100,000	6,000	6
Totals ..	3,300,100	428,316	686,110	89,620	13·06

* The figures for these countries are very tolerably reliable estimates of the realisable power.

"*The English Electric Journal*"
December 1954.

British Electricity—Research.

In July 1949, the British Electricity Authority set up the Electricity Supply Research Council with the following terms of reference:

"(a) to advise the Central Authority and Area Boards on specific problems relating to electricity supply;

(b) to keep under review matters affecting the supply and utilisation of electricity and to advice the Central Authority and Area Boards on programmes and planning of research carried out over the whole field; and

(c) to make recommendations to the Central Authority on research which the Council consider it desirable to initiate."

The members of the Council include eminent scientific authorities from outside the staff of the industry, as well as engineers of the Authority and the Area Boards, who constitute a body of scienctific advisers of wide experience and knowledge. The activities of the Council, which acts in a purely advisory capacity, are complementary to those of the various advisory research bodies appointed by the Government. In the latter connection it may be noted that the Authority are represented on the Advisory Council appointed by the Minister of Fuel and Power to advise him on scientific matters.

The Authority's research is predominantly concerned with engineering problems. The Research Liaison Committee, comprising representatives of Authority headquarters and of the Generation Divisions, are the co-ordinating body for all research on power station design and operation. To their four original sub-committees dealing respectively with boiler corrosion, flue-dust measurement, pyrites extraction, and the Pimlico district heating scheme were added during, 1952–53 five additional sub-committees dealing respectively with precipitator design, combustion, flue-dust deposition, effluent testing and the non-destructive testing of engineering materials.

Direct research on the laboratory scale is undertaken by the Authority at their main laboratories at Leatherhead and in specialised establishments at Croydon power station (insulator weathering trails, and circulating water cooling) and Grove Road power station, London (high pressure boiler corrosion). These facilities are scarcely sufficient to meet current requirements, and provision is being made for increased research accommodation and equipment.

Transmission and distribution problems tend to be of a different order from those relating to generation and here also there is a large measure of co-operation, between the Area Boards, the Authority and research associations.

On methods of use of electrical appliances and of electricity generally by consumers, there is close co-operation with the Electrical Research Association on the laboratory aspects of this type of research. At an early stage a Utilisation Research Committee of the Authorrity and the Area Boards was set up to direct investigations into such

matters as the load characteristics of the various classes of consumers and types of apparatus in general use, and to arrange for research into the related technical and economic aspects of supply.

Much research is undertaken through outside bodies. The Authority and the Area Boards make substantial contributions each year to the Electrical Research Association, with which are associated the plant manufacturers, as well as the electricity supply industry. The Association plays a leading role in research studies and are at present extending their laboratories so as to be able to expand their activities. The Authority and the Area Boards have undertaken to contribute over a period of three years a substantial sum towards the capital cost of these laboratories.

The Authority have also undertaken to contribute towards the research projects being carried out by the Ministry of Fuel and Power in connection with peat-burning and coal-burning gas turbines. In this work there has been close co-operation between the engineers of the Authority and those of the Ministry.

The Authority also subscribe annually to various other research associations such as the British Coal Utilization Research Association, and individual projects undertaken by the universities are encouraged, frequently financed by the Authority. The Authority have appointed a Committee on Research in Universities to consider, in the light of the existing programme of research into matters affecting the supply of electricity—

(*a*) the items of research in the fields of the physical and social sciences (both pure and applied) which the universities might appropriately undertake for and on behalf of the Authority;

(*b*) the university or universities in which particular research should be carried out; and

(*c*) the sums to be allocated to universities in respect of research to be undertaken by them.

This Committee consider all requests for financial assistance and are responsible for approving, within limits set by the Authority, research to be undertaken and the sums to be allocated thereto. In addition the Authority, subject to certain conditions, assist in the purchase of capital equipment which may be necessary for certain university projects. The policy of the Authority is to allow considerable freedom of initiative to all engaged in university research work.

"*Power and Prosperity*"
(British Electricity Authority).

The Invisible Cushion.

(By KENNETH F. WHITE)

Several months ago, explosives and power experts of Canadian Industries, Limited and the Hydro-Electric Power Commission of Ontario were faced with a tough blasting problem. It arose in the construction of the new 1,828,000 horse power generating station at Queenston, six miles below Niagara Falls.

The problem concerned the removal of a 12,000 cubic yard rock "plug." The plug had to be blasted out without damaging the No. 1 generating station, only 85 yards away.

LaPrairie suggested "if we release air in the water of the forebay between the plug and the plant at the same time as we blast the plug, the air bubbles rising to the surface of the water may cushion the blast effect."

A physicist and an engineer were assigned to investigate the effectiveness of the "air curtain." They used a tank of water, bisected by pipes through which they forced compressed air.

Sensitive pressure gauges were rigged up at one end of the tank and C.I.L. blasting caps were set off at the other. They arrived after two months of experiments at the most desirable quantity of air and size of bubble.

The results of these experiments were projected into full scale operation. A six-inch air line was connected to three three-inch pipes clamped together in a fixed position so that the centers would be nine inches apart. Each pipe was perforated with 36 small holes per foot. The complete unit was submerged on the bed of the forebay between the rock plug and the headworks of No. 1 generating station.

Blast holes drilled in the rock plug were now loaded with six tons of "Nitrone."

As an added precaution, Hydro workmen sandbagged the generating station headworks. However, "Lap" LaPrairie's air curtain, successfully reduced the blast effect reaching the headworks and no damage occurred. The resulting hammer (shock) transmitted through the water was absorbed by the air bubbles which were compressible and acted as a buffer.

The blast cleanly sliced out the plug. Yet the shock reaching the generating station was only 1/70 what it would have been without the air curtain.

The curtain was built up by forcing compressed air under 90 pounds pressure into the 250 foot long pipes ; 3,750 cubic feet of free air were pumped in each minute.

This air curtain was so successful that another unit was assembled and used while blasting the tailrace rock plug deep in the Niagara Gorge. This second air curtain was 750 feet long, and equally successful.

Both blasts were of the "split second" type a blasting technique which has been one of the notable features of Ontario Hydro's Niagara development.

The split-second technique uses electric blasting caps that set off charges 25/1,000 to 75/1,000 of a second apart. This results in greatly reduced seismic shock and better fragmentation, even with less explosive, than in other techniques using longer delays.

"C-I-L Oval"

June, 1954.

A new Plan for Reaping a Vast Harvest of Food from the Sea.

By EDWIN MULLER.

The little fishing vessel lay at anchor in the North Sea near Hamburg. Close to it two buoys were moored 60 feet apart. In the water below each buoy hung a metal plate connected by wires to the ship. They were the two poles of an electric circuit.

On deck two men sat before a screen like that of a television set. Occasionally a shadow wavered across the screen indicating that a fish was swimming between the two plates. The screen was part of the "echo sounder" with which most modern fishing vessels are equipped.

Suddenly a crowd of shadows appeared on the screen —a school of fish. One of the men threw a switch. A deep humming was heard. Down in the water electric current began leaping from pole to pole.

For a moment the fish swam crazily in circles. Then all of them swam straight towards one plate, behind which was a net. They were drawn along inexorably, like rats following a Pied Piper. Soon thousands of them were in the net.

This was an experiment conducted by a German scientist, Dr. Konrad Kreutzer. If its results can be applied commercially it may revolutionize the ocean-fishing industry.

The principle is that a fish, in the path of an electric current flowing between positive and negative poles,is forced to point towards the positive pole. And if the intensity of the current is varied in a certain rhythm the muscles of the fish's tail are made to contract and relax, propelling the fish towards that pole. A certain voltage propels the fish. A higher voltage stuns it temporarily. A still higher one kills it.

So far the method is more practical in fresh water than in salt, because salt water requires much more current. In ponds and rivers this method of fishing is already in use in some countries. And it opens great possibilities.

" *Reader's Digest* "
January, 1955.

New Steel Plant.

The Government of India have entered into an agreement with the German firms, Krupps and Demag, for the erection of a new steel plant with an initial capacity of 500,000 tons of ingots, to be increased eventually to 1,000,000 tons. The initial capital cost has been estimated at Rs. 72 crores of which the German combine is expected to provide Rs. 9·5 crores. The German investment will be for a period of ten years, with option to either side to continue the association for a further period of ten years. The exact amount of the German investment will depend on the value of the plant supplied by the combine. The combine will also be appointed as technical consultants and will receive a fixed fee of about Rs. 2·1 crores, which works out to about 3 per

Labour Cost and Productivity at Tata Iron and Steel Company's Works, Jamshedpur.

Year.	*Total saleable steel.*	*Average annual income per employee.*	*Average labour cost per ton.*	*Average output of finished steel per employee.*
	TONS.	RS.	RS.	TONS.
1939–40	777,000	768·41	31·54	24·36
1949–50	727,000	1,622·74	91·89	17·66
1950–51	784,000	1,851·81	94·47	19·60
1951–52	799,000	2,157·11	107·24	20·11
1952–53	784,000	2,206·53	110·84	19·91

cent of the estimated cost. No royalties are payable and no bonus shares will be issued. The consultants will act as representatives of the company management during the erection stage of the plant. Global tenders for supplies will be invited and the Minister of Production has announced that "quality prices and delivery of plant will be the determining factors in selecting suppliers irrespective of their nationalities."

" *The Engineer* "
April, 1954.

Symposium on River Valley Projects.

In the five-year plan there are eight projects costing Rs. 5 crores and more, 16 projects costing between Rs. 1 crore and Rs. 5 crores, 21 costing between Rs. 50 lakhs and Rs. 1 crore, 27 costing between Rs. 5 lakhs and Rs. 50 lakhs, and the rest are minor projects, the total numbering 232 in all and accounting between them for almost a half of the total outlay on the Rs. 2,069 crore plan. The Minister for Planning, who opened a recent symposium held under the auspices of the Central Board of Irrigation and Power in Delhi, said that this constituted a tremendous effort, considering the fact that the average yearly outlay was more than that during the preceding hundred years, and that not a single major project had been undertaken since 1930, a year that coincided with the general economic depression all over the world and marked political difficulties in India. Consequently there was only a handful of senior engineers with experience of heavy construction, and even these had little opportunity during the intervening years to keep themselves abreast of modern trends in project construction and evaluation. The symposium which had the blessing of the United Nations Economic Commission for Asia and Far East was held with a view to pooling the information and experience gained during the last seven years and advising the Government in the formulation of a central, co-ordinated policy for the projects and their benefits.

" *The Engineer* "
April 2, 1954.

Electricity Supply Finance.

Minister's Statement on Borrowing powers Bill.

Mr. Geoffrey LLoyd, the Minister of Fuel and Power, in moving the second reading in the House of Commons of the Gas and Electricity (Borrowing Powers) Bill last Friday, said:

Proposed Independent Inquiry.—Parliament had always considered that from time to time there should be a stocktaking in the national interest and it was the intention of the Government to have now an independent inquiry into the working of the nationalised electricity supply industry. He was happy to say that the Government had obtained the consent of Sir Edvin Herbert to preside over the inquiry. His long acquaintance with the industry and his independent position fitted him pre-eminently for the task. For the period of the enquiry he had freed himself from any professional obligations within the electricity supply industry. He would have associated with him Mr. F. G. Bagnall, managing director of British Nylon Spinners; Professor Ronald S. Edwards, the distinguished economist; Mr. Albert Healy, a director of the Dunlop Rubber Co., Mr. Lawrence Robson, an eminent accountant; and Mr. Jack Tanner, lately president of the A.E.U. and last year's chairman of the T. U. C.

The terms of reference which he had given to Sir Edwin, after consulting with the chairman of the Electricity Authority, were to inquire into the organization and efficiency of the eletricity supply industry in England and Wales in the light of its working under the Electricity Act of 1947, and to make recommendations.

The announcement was perhaps tactically timed to allay misgivings about the large increase in borrowing powers sought.

"Electrical Review"

July, 1954.

Germanium, the Unknown Element.

We call it the unknown element because the engineers and scientists who work with it say that the surface of its potentialities has hardly been scratched. While it has already been put to many uses and has obvious possibilities for others, those who know it say that it may very likely have a future significance comparable with electronic tubes which have brought us television, radio, radar, self-opening doors, and innumerable other devices and systems which were not even thought of until the tube came along to do the job.

What is Germanium?

First of all it's an element, number 32 in the list of 96 chemical elements. It's metallic, a little lighter than zinc or iron, but much more expensive. In a pure state it has the grey sheen of silver.

What is Germanium for?

In electronics, as the name implies, the handling of electrons, tiny particles of charge which fluctuate around the atom, is the important factor. Germanium has certain properties which enables it to handle

these electrons efficiently and cheaply. Because it is useful in such small quantities it promises extraordinary savings in the size and weight of the equipment in which it is used. Because it is an element in itself, with no little parts to go haywire inside of it, it promises to be practically indestructible if properly sealed up against contamination.

Because of all these factors—its cheapness, its efficiency, its usefulness in small sizes, and its dependability—it promises not only to make possible major improvements in existing electronic equipment but to lead to the development of new equipment, as yet undreamed of.

"Dial"

Vol. II- Issue I.

Microwave.

In recent years microwave communication equipment has experienced tremendous expansion in the world of communication.

Utilities, oil, and gas companies, with their long-range operational problems, and other right-of-way industries are faced with similar communication problems. They have approached, investigated, and adopted microwave naturally and easily as the one method of communication best suited to their purpose. And their reasons are good and sound; microwave eliminates wire lines and right of way, gives lower maintenance and installation; microwave is reliable, unaffected by nature with her wind and rain, sleet and storm, lightning and ice; microwave is versatile, providing voice communication, remote control, telemetering, facsimile, TV relay, etc.

The frequencies employed by microwave as assigned by the FCC are the 960, 2,000, and 7,000 megacycle bands, these areas being exclusively set apart for industrial point-to-point communication.

In mid-year 1950 there were approximately 2,000 miles of private microwave authorized in the United States. Two years later this figure had jumped to over 20,000 miles, conservative estimates of the 1955 total microwave mileage place the figure over 100,000 miles. There is little doubt that microwave is moving fast.

"Dial"

Vol. II. Issue 1.

German Concrete Poles Substituted for Wood.

Low-cost concrete poles for Germany's power lines are a success. Essentially, the concrete pole is a round, hollow, mast fabricated with steel reinforcement. Diameter of mast at top varies from 4½ to 15¾ inches, according to stress.

Mast length varies from 59 to 75 feet, depending on soil conditions.

The construction employs a centrifugal casting procedure. The mast is formed over steel reinforcement rods. The reinforcement structure is placed in a sheet-steel form with concrete mix of clay-free pit sand, pebbles, and concrete of ⅛ to ¼ in granulations. Rotation period is 10 to 20 min. at 350 to 500 rpm.

Erection is the same as used on wood and steel poles. Masts and cross arms are delivered separately to erection site and molded together on the ground with a high-quality cement.

"*McGraw-Hill Digest*"
March, 1954.

Stop Sign for Excavators.

Western Electric Co.'s Chicago plant employs red concrete to enclose its 12,000 V. underground power-distribution system. All plant construction men are instructed that, whenever they encounter this type of red concrete while excavating, all work must stop and the electrical department must be notified. It will take the necessary precautions.

"*McGraw-Hill Digest*"
March, 1954.

Power Generation.

In 1953, the average residential consumer of T.V.A. power used 4314 kwh, while the average in the United States was 2,257 kwh per annum. In the Tennessee Valley the average consumer increased his use by 387 kwh over the year before; in the country as a whole the increase was 166 kwh.

"*The Engineer*"
April 2, 1954.

When a fellow you knew at school attains some lofty public office, you're glad for his sake, but somewhat apprehensive for the future of the country.

Bill Vaughan.

It is a great thing to start life with a small number of really good books which are your very own.

Sherlock Holmes.

"*Reader's Digest*"
January, 1955.

Social and Personal

Sri D. Rajagopalan, Superintending Engineer, Projects circle, Madurai joined duty as Superintending Engineer, Technical (Civil) with effect from 12th January 1955 forenoon, vice Sri G. Venkataraman transferred as Superintending Engineer, General Construction Circle.

Sri G. Venkataraman joined duty as Superintending Engineer, General Construction Circle with effect from 7th January 1955 forenoon vice Sri K. M. Kuruvilla granted leave on average pay for four months.

Sri P. M. Chengappa, Superintending Engineer retired from service with effect from 24th January 1955 afternoon, Sri V. N. Swami, Assistant Engineer (Electrical) on 4th January 1955 afternoon and Sri Y. Dakshinamoorthy on 12th August 1954 afternoon.

Sri A. Subramanian, Divisional Electrical Engineer, Commercial -*cum*-Construction was reverted as Assistant Engineer (Electrical) with effect from 10th January 1955 forenoon and proceeded on leave for one month from that date.

Appreciation.

On the occasion of Sri C. V. Doraiswamy, Stores Accounts Officer, retiring from service on 1st November 1954, forenoon, the Chief Engineer for Electricity wishes to place on record his appreciation of the long, able and devoted service rendered by Sri Doraiswamy to the Department. The good wishes of the Department go to him for his health and happiness in his retirement.

On the occasion of Sri V. N. Swamy, Assistant Electrical Engineer, retiring from service on 4th January 1955, forenoon, the Chief Engineer for Electricity wishes to place on record his appreciation of the long, able and devoted service rendered by Sri V. N. Swamy to the Department. The good wishes of the Department go to him for his health and happiness in his retirement.

On the occasion of Sri P. M. Chengappa, Superintending Engineer (Civil) retiring from service on 24th January 1955, forenoon, the Chief Engineer for Electricity wishes to place on record his appreciation of the long, able and devoted service rendered by Sri P. M. Chengappa to the Department. The good wishes of the Department go to him for his health and happiness in his retirement.